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ABSTRACT

This paper reports on the design strategies and technical solutions that the authors have adopted to increase interaction in a World Wide Web-Based Instruction (WBI) system aimed at supporting new didactic approaches to the subjects of urban planning and architecture through the activation of online modules at the university level. Specifically, the developed system allows authorized users to modify the informative hypertext network dynamically. In addition, users can handle and re-elaborate the information published on the Web pages through specific working tools. The paper focuses on these tools from functional and technical points of view. The WBI system and innovative features are described, and strategies adopted in order to implement the system are summarized, including extending the information network, working on the information pages, and controlling the study path. An overview of system architecture and implementation is then provided. (Contains 23 references.) (MES)

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Enhancing User Interaction on the Web

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Abstract: Interaction with the information on the Web pages has been often reduced to the selection of links. This is a serious limit to all the Web applications that require an effective interaction with the information. Among the others, educational applications suffer from this limitation. Recent technologies, such as D-HTML and Java, are changing this, and opening up new interactive solutions on the Web. In this paper, we report on the design strategies and technical solutions we have adopted to increase interaction in a Web-Based Instruction system. In particular, but not exclusively, we have focused on the learning needs of university students on the subjects of Urban Planning and Architecture. Specifically, the developed system allows authorized users to modify the informative hypertext network dynamically; in addition, users can handle and re-elaborate the information published on the web pages through specific "working tools". The paper mainly focuses on these tools, from functional and technical points of view.

Introduction

The World Wide Web is fast emerging as one of the most popular technologies for education, since it allows educational institutions to potentially reach millions of people located all over the world [De Bra 98]. Specifically Web-Based Instruction systems, based on the integration of a rich hypermedia information system with powerful communication tools [Ibrahim et al. 95], have proved the instructional effectiveness of teaching and learning through the Web [Alexander 95].

However, some important features required for an effective use of the Internet in education are still missing from the Web. Limits concern many aspects of the Web, from presentation to interaction, from navigation to structure. Amongst the limits, we point out:

- The hypertext feature of the Web is extremely author-centered: users can only follow the hypertextual paths established by others (the page authors), but are not allowed modifying the existing links or adding new ones. Even if the available hypertextual navigation is a very important educational activity by itself, the impossibility of interacting with the information structure is a limit for educational applications.
- Information provided by the servers is usually in the form of web pages identical for all the students of on-line modules, rather than personalized pages.
- In html, information and its attributes (i.e., html tags) are mixed in the same document, thus making it difficult to work with automatic procedures aimed at elaborating the pure informative content [Andrews et al. 95].
- Interaction with the content of the pages is really poor, even though recent technologies provide interesting solutions.

More generally speaking, accessing a rich information environment -even if it is integrated with effective communication tools- is not a sufficient condition for expanding knowledge and stimulating learning. In fact, from a pedagogic point of view, learning requires "a deep understanding of the subject content" [Alexander 95] through a cognitive re-elaboration of the information [Colbourn 95].

Some design strategies can be adopted to overtake some limits of the Web. Research in this direction covers many aspects: from the hypertext organization of the information for individual learning paths [Oliver et al. 96] to the use of multiple media sources; from the publishing formats to the design of interfaces to reduce the cognitive overload; from the possibility of planning collaborative activities, to adaptive hypermedia [Brusilovsky 96] [De Bra 98], to the integration of tools which have proved particularly effective for stand alone educational hypermedia systems; and so forth.

In this paper we report on the design strategies we have adopted and on some specific tools we have developed to improve the interaction in a Web-Based Instruction (WBI) system. The system is aimed at supporting new

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didactic approaches to the subjects of Urban Planning and Architecture through the activation of on-line modules at University level.

Brief Introduction to the Developed WBI System and Innovative Features

The Web-Based Instruction system is organized in two "work areas" respectively named "Analysis Area" and "Design Area". The Analysis Area organizes-in a hypertextual way- the "external" information necessary for design activities in Architecture and Urban Planning (data on the town and on particular areas, the urban context for a new building, building regulations, administrative laws, formal and bibliography references, and so on).
The Design Area is directly aimed at some important phases of the design process in Architecture; it integrates Internet synchronous and asynchronous communication tools (e-mail, electronic discussion forums, video-conferencing, chatting) and tools to support the "control" of the project (virtual galleries, shared blackboard).
The Analysis Area represents an information repository for on-line educational modules activated on and managed through the system. The information in this area concerns, as a case study, the city of Palermo (Italy) and the design activities focus on, in particular, the sea front, in view of its future refurbishment.
In this paper, we do not present the Design Area in more details [Corrao et al. 99]; rather, we focus on the Analysis Area, by highlighting the interaction mechanisms implemented on it and their benefits in the educational field.
Actually, the system has been developed in such a way to provide different classes of users with different access facilities. Specifically, "students", "teachers" and "expert guests" can extend the information network interactively, by adding new pages and new (internal and external) links to the Analysis Area. "Students" can handle and re-elaborate the informative content of the pages; to this aim, we have implemented the "Working tools" which allow students to mimic effective traditional study activities. Changes operated on the Analysis Area can be "public", which means that they modify the original structure and content of the information network, and will be shown to all the classes of users; otherwise, changes are private to their author, so that they modify a "personalised" version of a web page in the Analysis Area (in addition, personalization can take into account some user's preferences, such as visualization preferences). Finally, "students", "teachers" and "tutors" can review the "study activities" performed during a specific study session (visited pages, operations on the page content, new added pages and links, and so on). We consider a "work session" as the set of operations performed by the user during two consecutive logs into the system.
Users gain access to the system through their Home Page [Fig. 1], corresponding to a personalized access point to the Design Area as well as to the Analysis Area.
Following, we report on the strategies we have adopted in order to implement the system.

Extending the Information Network

From a methodological point of view the possibility of extending the information network can improve learning through the construction of knowledge. This real interaction between students and the knowledge representation in the hypertext network is an important point towards a real and significant implementation of the Constructivist theory on the Web, by allowing for the development of personalized in-depth research sections [Schank 94]; the possibility of extending the information network allows teachers and expert guests to enrich the content of the system too. Finally, the privileges accorded to specific classes of users prevent guests from arbitrarily adding information to the system.
The possibility of extending the information network rises important theoretical and technical questions about the parameters to be fixed in order to guarantee a consistent growth of an on-line informative hypertextual network. Firstly, we have focused on a very precise model of the information domain, and imposed an a-priori organization of information; in such a way, new nodes can be immediately classified in some pre-defined category (and added to the right place in the network). Secondly, we have imposed some limits to the extension mechanism, both at information node and link levels; particular attention has been paid to the types of links users can add to the system. These constraints have been fixed in such a way to preserve the original structure of the network, yet allowing people to add new pieces of information. Moreover, it is extremely important to keep information about each node and link author, in order to guarantee source reliability. Finally, it has been necessary to provide system known users with mechanisms showing modifications to the network since their last access.

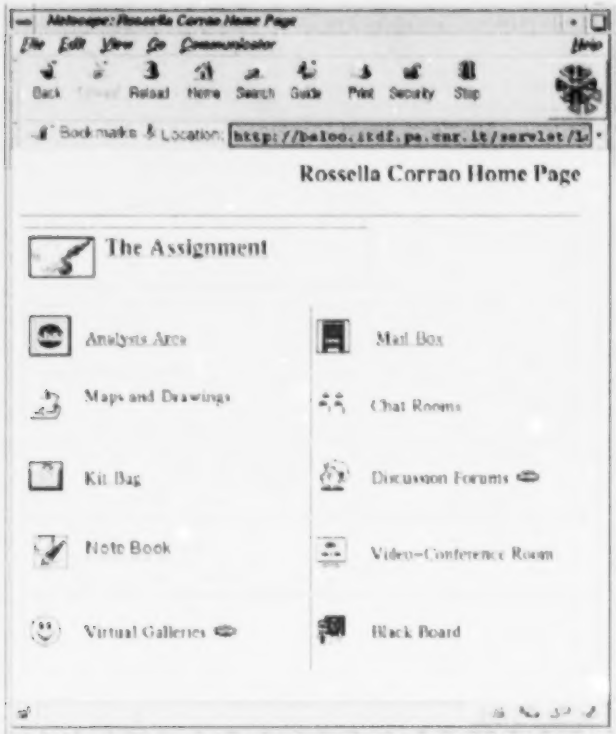

Fig. 1. The user Home Page is the personal entry point to system.

Specific tools have been developed to allow users to add nodes and associative links. By selecting a "New Page" button [Fig. 2], the user can add the content of the new page through a preformatted form; afterwards, s/he is guided to identify the category of information the new node is to be classified. Through the "New Link" button, the user can select the link anchor by interacting directly with the text on the page, through a common click-and-drag operation on the text; then, she is guided to select the link destination.
New added pages and links are public to all the system users, and not only to their authors, thus providing for learning activities based on cooperative production of knowledge.

Working on the Information Pages

The "working tools" sustain the user's attention at high level and develop his/her critical sense and his/her abilities to search for, extract and synthesize information. Specifically, we refer to the tools that allow the users to mimic traditional activities, through a series of stationery items like "Marker", "Foot-Note" and "Page-mark". These tools, together with the "Note-book" and the "Kit bag", enable the user to handle and manipulate the information in the web pages. Changes to the page content are private to the user who makes the modification. The philosophy of these tools is, in fact, the provision of mechanism for individual study strategies. In addition, making private modifications available to all the users could produce a chaotic representation of the information.
The *"Marker" tool* allows parts of the text on the pages to be highlighted. The selected parts remain highlighted until the end of the on-line module; in addition, the user can decide whether and when to transform these selected parts into real informative documents by putting them into the "Kit bag". The *" Foot-Note" tool* allows the user to add notes, reference-marks and other information to the text of a page. The notes, which are for the private use of the user who created them, remain "attached" to the pages from one on-line work session to another. During first reading, the user can "mark" each page of the system s/he considers relevant to his/her studies by using the *"Page-mark" tool* (activated through a specific button [Fig. 2]); the user can navigate back

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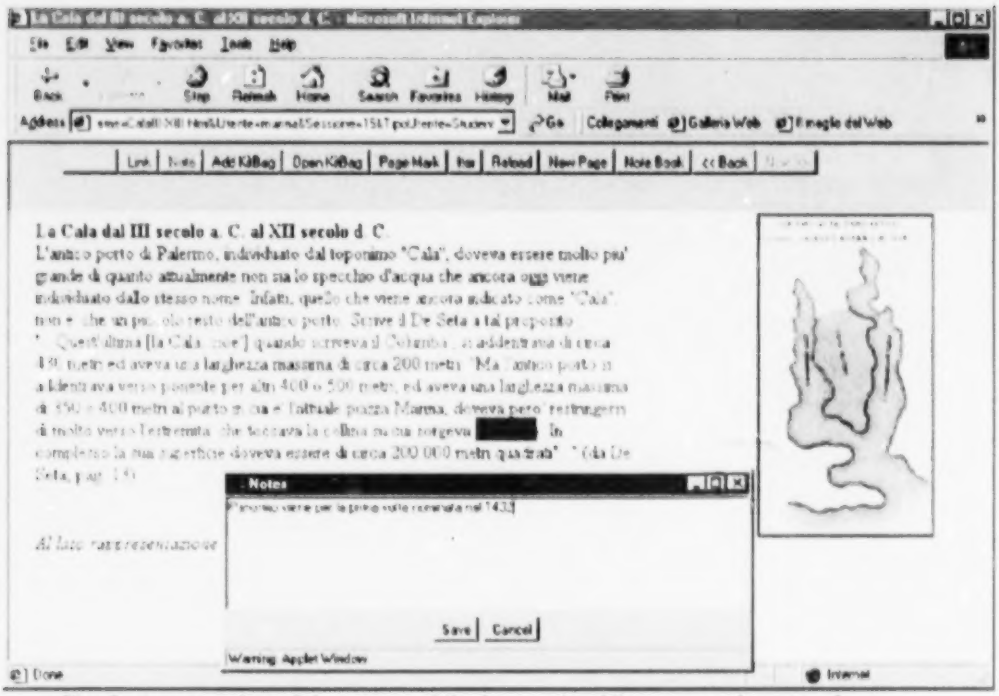

Fig. 2: A screen shot of the system while the user is adding a note; the upper frame contains the "working tools" buttons and the buttons to extend the information network.

to the marked pages through the "Iter" tool (refer to [Controlling Oneself Study Path]) to study these pages in more detail. The *"Note-book" tool* works like a real note-book enabling the user to write down reflections, critical notes, and so on; for this reason it represents a collection of writing sheets. It is activated through the Note-book button [Fig. 2]. The user can access the Note-Book in the Design Area and pass through the different notes taken during the navigation across the Analysis Area. The tool "Iter" highlights the presence of footnotes on the pages. Finally, the *"Kit bag" tool* represents a kind of catalogue that the users carry with them during navigation through the system, and where they store pieces of information collected on this way around. The pieces of information in the "Kit bag" retain the reference to their original web page; therefore, it is possible for the user to go back to the page, and choose links to other parts of the system. Furthermore, users carry the "Kit bag" with them in the "Design Area". The user interaction with the "Foot-Note", "Marker" and "Kit bag" tools is extremely easy and rapid: once the corresponding button has been selected [Fig. 2], the user selects (through the click-and drag mechanism) the chunk of text which is, respectively, the anchor for the note, the text to be marked or the piece of text to be inserted into the kit bag.

Controlling Oneself Study Path

One of the most effective tools to help the users navigate through the information is the *"Iter" tool*: it shows the list of pages visited during each work session or since a date specified by the user. Unlike the "history" tool available in commercial browsers, the "Iter" tool keeps track of the operation performed on the pages through the tools described above. In particular, next to the name of every page, there are symbols to indicate the operation carried out by the user, so s/he may locate the information s/he considered important and return there directly. The same information can be accessed by the teachers and the tutors of the on-line modules, thus controlling and assessing the students' activities in the system. Non-technical teachers can, therefore, work with the system and perform assessment activities in a very easy way.

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It should be noted that some of the described activities could already be performed by using features of the browsers and of the most popular operating systems. However, these solutions are unsatisfactory because the mechanisms are not integrated into a single environment, they are usually separated from the learning/reading context (the informative content of the Web pages), and require a cognitive overload on the part of the learner/reader.

System Architecture and Implementation Overview

The implementation of the system is strongly centered on Java ™, both on the client-side and on the server-side. Specifically, Java Applets are used to host the text and to handle the user interaction; on the server side, the system is managed by a set of Servlets; to be more precise, servlets handle the mechanism necessary to provide the personalised pages to each registered user and to log all the user's operations. To this aim, an SQL-compatible Data Base is used to store information about the registered users (login, password, visualization preferences, and so forth), specific information belonging to each user (references to the file containing the personal notes added during the navigation, references to the information stored into the kit bag, and so on) and information on the modifications that each user has made on each page of the system. In particular, the system stores four different files for each page in the Analysis Area: the html page, containing the page layout, the file containing the pure text, the file of the public attributes (html formatting tags, link tags) and the file of the private attributes (to be more precise, there is one "private" file for each registered user). The separation between content, layout and attributes greatly improves the management of the personal versions of the pages. Finally, a Web Server, used to deliver html pages to the browser completes the system architecture.

When a registered user logs into the system, a specific servlet sends the user's Homepage to the client. As told before, the Homepage represents the personal entry point to all the parts of the system, included the Analysis Area; in order to guarantee the deliver of the personal pages of the Analysis Area to each user, all the URLs contained in the HomePage are modified in such a way to include its owner's ID. The ID will enable the servlets to identify the origin of each request. Specifically, when the client requires a page of the Analysis Area, an applet sends the modified URL to a specific servlet (ReqDocument), together with indication of the file containing the text as parameter; then, the applet sets up a *channel* which is used by the servlet to deliver the document. The particular servlet to be activated and the parameters (if required) are also included into the URL sent by the browser. The ReqDocument servlet builds the document by merging all the information contained in the four files reported before. When the document is received by the client, the applet interprets the tags included in the document, divides the text into the lines which will appear on the page, builds two arrays for each line containing the pure text (line_text) and the text inclusive of the tags (line_tag), and finally displays the document. The two arrays are necessary to handle the click-and-drag operation on the text.

The set of tags, which the applet is able to interpret, is a reduced sub-set of html tags together with new proprietary tags defined by the authors to encode the user changes to the text.

The selection of chunks of text on the page through the click-and-drag mechanism (which is central to many operations) is handled by the applet that hosts the text.

When a chunk of text is selected and the user operates on it through one of the tools described above, a communication process between the applet which handles the operative buttons [Fig. 2] and the applet hosting the text is started, so that the selected text is modified according to the operation selected by the user. In addition, the notification of the user action and of the words affected by it is sent to the server, so that the DataBase and the specific files are modified.

Some examples of the working mechanism for the most significant tools are reported. By selecting the Marker tool, the system modifies the background color of the selected text and communicates the event to the server; by activating the Foot-Note tool, the system opens a Java frame external to the browser, thus allowing the user to add the note [Fig. 2]; afterwards, it adds a symbol at the end of the selected text in order to anchor the footnote, and passes the event (including the note content) to the server; finally, by choosing Link button, the applet opens a Java frame external to the browser, allowing the user to select the page to be linked to the new created link, or directly writing the URL (internal and external URL's can be specified by the user); the new link is passed to the server.

The developed prototype is running on Windows NT platform equipped with Apache Web Server and Microsoft Access Database.

Conclusions and Future Developments

In this paper, we have proposed some design and technical solutions to improve interaction in a Web-Based Instruction system. Specifically, we have introduced the design strategies which allow users to extend the information network, and some "working tools" which can maximize the learning and reading processes and facilitate the recognition of the phases of knowledge acquisition. Even if the presented system concerns a specific subject, and is aimed at University studies level, the working tools should be considered as general solutions for educational systems. The Analysis Area can be substituted straightforwardly, thus widening the use of the system to different application fields. Anyway, a rigorous definition of the knowledge domain is necessary to allow for a consistent growth of the Analysis Area. Finally, the communication tools in the Design Area can be easily adapted for different educational contexts, and new tools can be integrated into it. The main limit of the Java based implementation is the restricted number of html tags the system recognizes in order to reduce the complexity of the interpretation work; consequently, an appropriate tradeoff between complexity and effectiveness should be investigated further. There are some other important developments we foresee for the presented system: firstly, it is possible for the servlet mechanism to work with distributed data base; secondly, some operations on the text which have been defined "private" can be straightforwardly made public, and vice versa, according to the user's decision and to the use context of the system. Finally, division between pure text and text attributes makes it possible the implementation of effective automatic procedures on the text.

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